

Aerosol source attributions and source-receptor relationships across the Northern Hemisphere

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1. Objectives

- Examine the transport of aerosols, including anthropogenic, dust, and biomass burning, from source regions to downwind regions
- Assess the emission and transport impacts on regional and global air quality, ecosystems, public health, and climate
- Provide information on potential emission mitigation options

2. Approaches

- Hemispheric transport of air pollution (HTAP) is a UN TF HTAP coordinated international assessment activity to assess these objectives. Initial results of two HTAP2 models (GOCART and GEOS-5) are used in this analysis.
- Measurements from satellite, aircraft and ground networks are used to evaluate the models.
- Investigating aerosol source attributions and source-receptor relations across the Northern Hemisphere from surface concentration and column-wise perspective.
- Response to extra-regional emission reduction (RERER or R) is calculated as

$$R_i = \frac{\Delta C_{i,glo} - \Delta C_{i,rgn}}{\Delta C_{i,glo}}$$

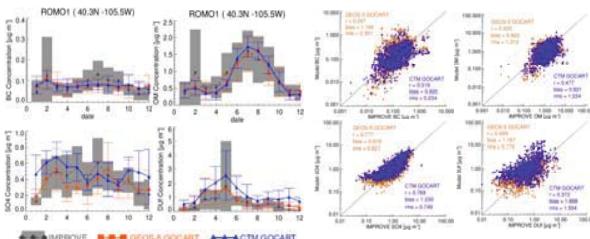
For each region i , R_i is the regional concentration change due to the extra-regional emission reduction relative to that due to the global emission reduction (regional + extra regional)

3. Model set up

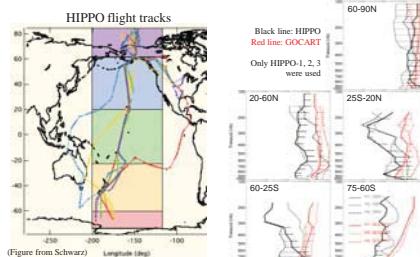
- Emissions:
 - Anthropogenic: HTAP2, 0.1x0.1 deg, 4 sectors (energy, industry, residential, transportation)
 - Biomass burning: GFED v3 (recommended)
 - Volcanic: HTAP2/AeroCom-MAP (Thomas Diehl)
 - Dust and sea salt: Model calculated
- High priority runs:
 - BASE, 2008-2010
 - 20% reduction of anthropogenic emissions in GLO, NAM, EUR, EAS, SAS, RBU, and MDE
 - Zero-out dust emissions in NAF, CAS, EAS, MDE
 - 20% reduction of global fire emissions

4. Model Evaluation

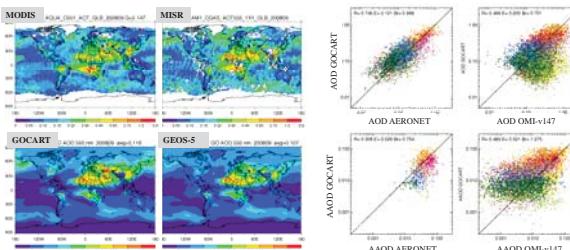
Surface BC, OC, SO₄, Duf concentration from IMPROVE network



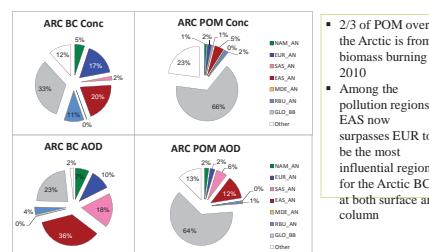
BC vertical profile from the HIPPO aircraft campaign



AOD and AAOD from satellites and AERONET



5. In the Arctic – where are the carbonaceous aerosols from?



• 2/3 of POM over the Arctic is from biomass burning in 2010

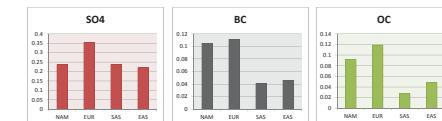
• Among the pollution regions, EAS now surpasses EUR to be the most influential region for the Arctic BC at both surface and column

6. Response to Extra-Regional Emission Reduction (RERER)

RERER (or R): see its definition in Approaches

- The lower the R_i , the less sensitive the amount within a region to the extra-regional emission reduction (or the more sensitive to the emission reduction within its own region)

Surface concentration – GOCART anthropogenic

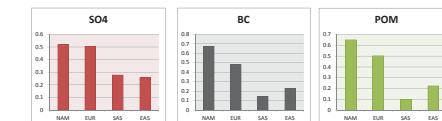


EUR is most sensitive to extra-regional SO2 emission change

SAS and EAS are least sensitive to extra-regional BC emission change

EUR is most and SAS is least sensitive to extra-regional OC emission change

AOD – GOCART anthropogenic



NAM and EUR are much more sensitive to extra-regional SO2 emission change than SAS and EAS

NAM is most sensitive and SAS is least sensitive to extra-regional BC emission change

NAM is most sensitive and SAS is least sensitive to extra-regional OC emission change

7. Conclusions

- GOCART and GEOS-5 model simulated aerosol mass and AOD are in general consistent measurements.
- Compared with in-situ measurements, the model does not have systematic bias of surface BC concentrations in the US, but it significantly overestimates BC concentrations at the remote free troposphere.
- The surface concentrations of BC over the NH polluted regions are predominantly from their own regional pollution sources, while the source attribution for surface POM is quite different between NAM/EUR and SAS/EAS, as the former more influence by extra-regional sources or other sources
- Column-wise, there is also a sharp difference between NAM/EUR and SAS/EAS, as the former generally overwhelmed by the extra-regional or other sources
- Biomass burning and Asian pollution contributes to 60-80% of carbonaceous aerosols in the Arctic
- The results imply that the long-range transport of carbonaceous aerosol can significantly alter the regional climate and weather